

The Mole and Equations

This is the moment where the 'mole of moles' comes in. It's the equation from page 104 that makes it all work.

You Can Use Moles to Calculate Masses in Reactions

Remember those balanced equations back on page 100? Well, the **balancing** numbers (the chemical formulae of the reactants and products) tell you how much of each substance takes part in or is formed during the reaction.

For example:



In this reaction, **1 mole** of magnesium and **2 moles** of hydrochloric acid react together to form **1 mole** of magnesium chloride and **1 mole** of hydrogen gas.

You Can Balance Equations Using Reacting Masses

If you know the **masses** of the **reactants** and **products** that took part in a reaction, you can work out the **balanced symbol equation** for the reaction. Here are the steps you should take:

1. Write the **mass** of each substance by its **relative formula mass** for that the **number of moles**.
2. Write the **number of moles** of each substance by the **symbol number of moles** in the reaction.
3. If any of the numbers aren't whole numbers, multiply all the numbers by the same amount so that they all become whole numbers.
4. Write the **balanced symbol equation** for the reaction by putting these numbers in front of the chemical formulae.

EXAMPLE 1

81 g of zinc with CuSO_4 reacts completely with 0.80 g of carbon to form 32 g of carbon dioxide and 65 g of zinc. Write a balanced symbol equation for this reaction.

1. Work out by its mass of the substance in the reaction.
 $81 \times 10 = 810$ $0.80 \times 12 = 9.6$ $32 \times 44 = 1408$ $65 \times 65 = 4225$

2. Divide the mass of each substance by its 10 to calculate the number of moles of each substance reacted or made.

$$\text{Zn} \quad \frac{81}{10} = 8.1 \text{ moles}$$

$$\text{C} \quad \frac{0.80}{12} = 0.067 \text{ moles}$$

$$\text{CO}_2 \quad \frac{32}{44} = 0.727 \text{ moles}$$

$$\text{Zn} \quad \frac{65}{65} = 1.0 \text{ mole}$$

3. Check if the numbers are whole, which is 0.067.

$$81 \times 0.067 = 5.4$$

$$\text{C} \quad 0.067 \times 12 = 0.8$$

$$\text{CO}_2 \quad 0.067 \times 44 = 2.9$$

$$\text{Zn} \quad 0.067 \times 65 = 4.4$$

4. The numbers are all whole numbers, so you can use the balanced symbol equation straight away.
 $5.4\text{Zn} + 0.8\text{C} \rightarrow 2.9\text{CO}_2 + 4.4\text{Zn}$

These numbers give 10 times as many moles of each substance as the balanced equation.



Where do moles live? Digaburrow...

The calculations on this page have lots of steps, so the best way to learn how to do them is to practice. Luckily, there are some questions below to get you started. Don't say I didn't warn you. Most of the questions are marked with a star.

1. 10 g of Zn reacts completely with 10 g of HCl to produce 10 g of ZnCl₂.
 $\text{Zn} + 2\text{HCl} \rightarrow \text{ZnCl}_2 + \text{H}_2$
2. Calculate how many moles of each substance reacted or was produced.
3. Use your answers to put up a balanced symbol equation for this reaction.

(1 mark)
(2 marks)

Limiting Reactants

Reactions don't go on forever — you need stuff in the reaction that can react. If one reactant gets **used up** in a reaction before the rest, then the reaction will **stop**. That reactant's called **limiting**.

Reactions Stop When One Reactant Is Used Up

When some **magnesium carbonate** (MgCO_3) is placed into a beaker of **hydrochloric acid**, you can tell a **reaction** is taking place because you see lots of **bubbles of gas** being given off. After a while, the amount of **acid** **disappears** and the reaction **eventually stops**.

1. The reaction stops when all of one of the reactants is **used up**. Any other reactants are in **excess**. They're usually added in excess to **make sure** that the other reactant is used up.
2. The reactant that's **used up** in a reaction is called the **limiting reactant** (because it limits the amount of product that's formed).
3. The amount of product formed is **directly proportional** to the amount of **limiting reactant**. For example, if you **halve** the amount of limiting reactant the amount of product formed will also **halve**. If you **double** the amount of limiting reactant the amount of product will **double** (as long as it is still the limiting reactant).
4. This is because if you add **more reactant** there will be **more product particles** to take part in the reaction, which means **more product particles**.



The Amount of Product Depends on the Limiting Reactant

You can calculate the **mass of a product** formed in a reaction by using the **mass of the limiting reactant** and the **balanced reaction equation**.

1. Write out the **balanced equation**.
2. Work out **relative formula masses** (M_r) of the reactant and product you want.
3. Find out **how many moles** there are of the substance you know the mass of.
4. Use the balanced equation to work out **how many moles** there'll be of the **other** substance. In this case, that's how many moles of **product** will be made of the many moles of **reactant**.
5. Use the number of moles to calculate the **mass**.

The limiting reactant is the one that gets used up first. It's the one that limits the amount of product that can be made.

EXAMPLE 2

Calculate the mass of aluminium oxide formed when 105 g of aluminium is burned in air.

1. Write out the **balanced equation**.
 $4\text{Al} + 3\text{O}_2 \rightarrow 2\text{Al}_2\text{O}_3$
2. Calculate the **relative formula masses**.
 $4 \times 27 = 108$ $3 \times 32 = 96$ $2 \times 102 = 204$
3. Calculate the **number of moles** of aluminium = 105 g.
 $\text{moles} = \frac{\text{mass}}{M_r} = \frac{105}{27} = 3.89$
4. Look at the **ratio of moles** in the equation.
 If the equation says for the number of moles of aluminium, then for every 4 moles of Al, you need 3 moles of O₂.
 So 3.89 moles of Al will need 2.92 moles of O₂.
 2.92 moles of Al₂O₃.
 So 3.89 moles of Al will make 2.92 moles of Al₂O₃.
 mass = moles $\times M_r = 2.92 \times 102 = 298$ g

'A Dash of Mad to the Head' — my favourite album by Madness

I want to tell you, it's not a game — practice makes perfect. So before you get down to work, here are some questions to get you started. Don't say I didn't warn you.

1. The balanced equation for the reaction between aluminium and potassium hydroxide is:
 $2\text{Al} + 2\text{KOH} \rightarrow 2\text{KAlO}_2 + \text{H}_2$
2. Calculate the mass of potassium hydroxide produced when 13.5 g of aluminium reacts with an excess of potassium hydroxide.

(1 mark)

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A Loxley



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